

## Appendix B. Descriptions of Model Building Types

Table B.1 lists 36 model building types which have been defined for the methodology. The classification system is based on the classification system of FEMA-178 (1992). By reviewing the table it can be seen that there are 16 basic building types (shown in bold) with some building types being subdivided with respect to height. Each basic building class is defined by a short description of its structural system. These descriptions are based on FEMA-178 and follow Table B.1.

**Table B.1 Structural Building Classifications (Model Building Types)**

No.	Label	Description	Height
1	W1	Wood, Light Frame (W1)	ALL
2	W2	Wood, Commercial and Industrial (W2)	ALL
		<b>Steel Moment Frame (S1)</b>	
3	S1L	Low-Rise	1-3
4	S1M	Mid-Rise	4-7
5	S1H	High-Rise	8+
		<b>Steel Braced Frame (S2)</b>	
6	S2L	Low-Rise	1-3
7	S2M	Mid-Rise	4-7
8	S2H	High-Rise	8+
9	S3	Steel Light Frame (S3)	
		<b>Steel Frame w/ Cast-in-Place Concrete Shear Walls (S4)</b>	
10	S4L	Low-Rise	1-3
11	S4M	Mid-Rise	4-7
12	S4H	High-Rise	8+
		<b>Steel Frame w/ Unreinforced Masonry Infill Walls (S5)</b>	
13	S5L	Low-Rise	1-3
14	S5M	Mid-Rise	4-7
15	S5H	High-Rise	8+
		<b>Reinforced Concrete Moment Resisting Frame (C1)</b>	
16	C1L	Low-Rise	1-3
17	C1M	Mid-Rise	4-7
18	C1H	High-Rise	8+
		<b>Concrete Shear Walls (C2)</b>	
19	C2L	Low-Rise	1-3
20	C2M	Mid-Rise	4-7
21	C2H	High-Rise	8+
		<b>Concrete Frame Buildings w/ Unreinforced Masonry Infill Walls (C3)</b>	
22	C3L	Low-Rise	1-3
23	C3M	Mid-Rise	4-7
24	C3H	High-Rise	8+

**Table B.1 Cont. Structural Building Classifications (Model Building Types)**

No.	Label	Description	Height
		Precast-Concrete Tilt-Up Walls (PC1)	
25	PC1	Low-Rise	ALL
		<b>Precast Concrete Frames w/ Concrete Shear Walls (PC2)</b>	
26	PC2L	Low-Rise	1-3
27	PC2M	Mid-Rise	4-7
28	PC2H	High-Rise	8+
		<b>Reinforced Masonry Bearing Walls w/ Wood or Metal Deck Diaphragms</b>	
29	RM1L	Low-Rise	1-3
30	RM1M	Mid-Rise	4+
		<b>Reinforced Masonry Bearing Walls w/ Precast Concrete Diaphragms</b>	
31	RM2L	Low-Rise	1-3
32	RM2M	Mid-Rise	4-7
33	RM2H	High-Rise	8+
		<b>Unreinforced Masonry Bearing Walls (URM)</b>	
34	URML	Low-Rise	1-2
35	URMM	Mid-Rise	3+
36	MH	Mobile Home (MH)	

**B.1 Wood, Light Frame (W1):**

These are typically single- or multiple-family dwellings. The essential structural feature of these buildings is repetitive framing by wood rafters or joists on wood stud walls. Loads are light and spans are small. These buildings may have relatively heavy masonry chimneys and may be partially or fully covered with masonry veneer. Most of these buildings, especially the single-family residences, are not engineered but constructed in accordance with “conventional construction” provisions of building codes. Hence, they usually have the components of a lateral-force-resisting system even though it may be incomplete. Lateral loads are transferred by diaphragms to shear walls. The diaphragms are roof panels and floors which may be sheathed with wood, plywood or fiberboard sheathing. Shear walls are exterior walls sheathed with boards, stucco, plaster, plywood, gypsum board, particle board, or fiberboard, or interior partition walls sheathed with plaster or gypsum board.

**B.2 Wood, Commercial and Industrial (W2):**

These buildings usually are commercial or industrial buildings with a floor area of 5,000 square feet or more and with few, if any, interior walls. The essential structural character of these buildings is framing by beams or major horizontally spanning members over columns. These horizontal members may be glued-laminated (glu-lam) wood, solid-sawn wood beams, or wood trusses, or steel beams, or trusses. Lateral loads usually are resisted by wood diaphragms and exterior walls sheathed with plywood, stucco, plaster, or other paneling. The walls may have diagonal rod bracing. Large openings for storefronts and garages often require post-and-beam framing. Lateral load resistance on those lines may be achieved with steel rigid frames (moment frames) or diagonal bracing.

**B.3 Steel Moment Frame (S1):**

These buildings have a frame of steel columns and beams. In some cases, the beam-column connections have very small moment resisting capacity but, in other cases, some of the beams and columns are fully developed as moment frames to resist lateral forces. Usually the structure is concealed on the outside by exterior walls, which can be of almost any material (curtain walls, brick masonry, or precast concrete panels), and on the inside by ceilings and column furring. Lateral loads are transferred by diaphragms to moment resisting frames. The diaphragms can be almost any material. The frames develop their stiffness by full or partial moment connections. The frames can be located almost anywhere in the building. Usually the columns have their strong directions oriented so that some columns act primarily in one direction while the others act in the other direction. Steel moment frame buildings are typically more flexible than shear wall buildings. This low stiffness can result in large interstory drifts that may lead to relatively greater nonstructural damage.

**B.4 Steel Braced Frame (S2):**

These buildings are similar to steel moment frame buildings except that the vertical components of the lateral-force-resisting system are braced frames rather than moment frames.

**B.5 Steel Light Frame (S3):**

These buildings are pre-engineered and prefabricated with transverse rigid frames. The roof and walls consist of lightweight panels, usually corrugated metal. The frames are designed for maximum efficiency, often with tapered beam and column sections built up of light steel plates. The frames are built in segments and assembled in the field with bolted joints. Lateral loads in the transverse direction are resisted by the rigid frames with loads distributed to them by diaphragm elements, typically rod-braced steel roof framing bays. Loads in the longitudinal direction are resisted entirely by shear elements which can be either the roof and wall sheathing panels, an independent system of tension-only rod bracing, or a combination of panels and bracing.

**B.6 Steel Frame with Cast-In-Place Concrete Shear Walls (S4):**

The shear walls in these buildings are cast-in-place concrete and may be bearing walls. The steel frame is designed for vertical loads only. Lateral loads are transferred by diaphragms of almost any material to the shear walls. The steel frame may provide a secondary lateral-force-resisting system depending on the stiffness of the frame and the moment capacity of the beam-column connections. In modern “dual” systems, the steel moment frames are designed to work together with the concrete shear walls in proportion to their relative rigidities.

**B.7 Steel Frame with Unreinforced Masonry Infill Walls (S5):**

This is one of the older types of buildings. The infill walls usually are offset from the exterior frame members, wrap around them, and present a smooth masonry exterior with

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no indication of the frame. Solidly infilled masonry panels, when they fully engage the surrounding frame members (i.e. lie in the same plane), provide stiffness and lateral load resistance to the structure.

### **B.8 Reinforced Concrete Moment Resisting Frames (C1):**

These buildings are similar to steel moment frame buildings except that the frames are reinforced concrete. There is a large variety of frame systems. Some older concrete frames may be proportioned and detailed such that brittle failure of the frame members can occur in earthquakes, leading to partial or full collapse of the buildings. Modern frames in zones of high seismicity are proportioned and detailed for ductile behavior and are likely to undergo large deformations during an earthquake without brittle failure of frame members and collapse.

### **B.9 Concrete Shear Walls (C2):**

The vertical components of the lateral-force-resisting system in these buildings are concrete shear walls that are usually bearing walls. In older buildings, the walls often are quite extensive and the wall stresses are low but reinforcing is light. In newer buildings, the shear walls often are limited in extent, thus generation concerns about boundary members and overturning forces.

### **B.10 Concrete Frame Buildings with Unreinforced Masonry Infill Walls (C3):**

These buildings are similar to steel frame buildings with unreinforced masonry infill walls except that the frame is of reinforced concrete. In these buildings, the shear strength of the columns, after cracking of the infill, may limit the semiductile behavior of the system.

### **B.11 Precast Concrete Tilt-Up Walls (PC1):**

These buildings have a wood or metal deck roof diaphragm, which often is very large, that distributes lateral forces to precast concrete shear walls. The walls are thin but relatively heavy while the roofs are relatively light. Older buildings often have inadequate connections for anchorage of the walls to the roof for out-of-plane forces, and the panel connections often are brittle. Tilt-up buildings usually are one or two stories in height. Walls can have numerous openings for doors and windows of such size that the wall looks more like a frame than a shear wall.

### **B.12 Precast Concrete Frames with Concrete Shear Walls (PC2):**

These buildings contain floor and roof diaphragms typically composed of precast concrete elements with or without cast-in-place concrete topping slabs. The diaphragms are supported by precast concrete girders and columns. The girders often bear on column corbels. Closure strips between precast floor elements and beam-column joints usually are cast-in-place concrete. Welded steel inserts often are used to interconnect precast elements. Lateral loads are resisted by precast or cast-in-place concrete shear walls. For buildings with precast frames and concrete shear walls to perform well, the details used

to connect the structural elements must have sufficient strength and displacement capacity; however, in some cases, the connection details between the precast elements have negligible ductility.

### **B.13 Reinforced Masonry Bearing Walls with Wood or Metal Deck Diaphragms (RM1):**

These buildings have perimeter bearing walls of reinforced brick or concrete-block masonry. These walls are the vertical elements in the lateral-force-resisting system. The floors and roofs are framed either with wood joists and beams with plywood or straight or diagonal sheathing, or with steel beams with metal deck with or without a concrete fill. Wood floor framing is supported by interior wood posts or steel columns; steel beams are supported by steel columns.

### **B.14 Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms (RM2):**

These buildings have bearing walls similar to those of reinforced masonry bearing wall structures with wood or metal deck diaphragms, but the roof and floors are composed of precast concrete elements such as planks or tee-beams and the precast roof and floor elements are supported on interior beams and columns of steel or concrete (cast-in-place or precast). The precast horizontal elements often have a cast-in-place topping.

### **B.15 Unreinforced Masonry Bearing Walls (URM):**

These buildings include structural elements that vary depending on the building's age and, to a lesser extent, its geographic location. In buildings built before 1900, the majority of floor and roof construction consists of wood sheathing supported by wood subframing. In large multistory buildings, the floors are cast-in-place concrete supported by the unreinforced masonry walls and/or steel or concrete interior framing. In unreinforced masonry constructed after 1950 wood floors usually have plywood rather than board sheathing. In regions of lower seismicity, buildings of this type constructed more recently can include floor and roof framing that consists of metal deck and concrete fill supported by steel framing elements. The perimeter walls, and possibly some interior walls, are unreinforced masonry. The walls may or may not be anchored to the diaphragms. Ties between the walls and diaphragms are more common for the bearing walls than for walls that are parallel to the floor framing. Roof ties usually are less common and more erratically spaced than those at the floor levels. Interior partitions that interconnect the floors and roof can have the effect of reducing diaphragm displacements.

### **B.16 Mobile Homes (MH):**

These are prefabricated housing units that are trucked to the site and then placed on isolated piers, jackstands, or masonry block foundations (usually without any positive anchorage). Floors and roofs of mobile homes usually are constructed with plywood and outside surfaces are covered with sheet metal.

